ONTARIO WATER RESOURCES COMMISSION

REPORT on WATER QUALITY in BALSAM LAKE 1971

RECREATIONAL LAKES PROGRAM

BBCS

Environment Ontario

THE

ONTARIO WATER RESOURCES COMMISSION

REPORT

ON WATER QUALITY

IN

BALSAM LAKE

1971

GENERAL TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUMMARY

A study to evaluate the status of water quality in Balsam Lake was carried out during the summer of 1971.

Balsam Lake lies in the Trenton Bedrock Formation which is flat limestone bedrock buried beneath a mantle of different textured materials having good local drainage. The shoreline is composed of a variety of top soils ranging from fine sandy to coarse gravelly loams. With the exception of the Otonabee loam and the Cramahe Gravel, the nature of the soil can be considered as unsuitable for the installation of standard subsurface septic tank systems.

A zone of rapid temperature decline was apparent immediately above the bottom in June. During this period, bottom water concentrations of dissolved oxygen were lower and carbon dioxide values were higher than in the surface waters, resulting from decomposition of organic matter. Distinct temperature zones were not present during the summer and fall surveys owing to wind-induced vertical mixing processes.

The low to moderately productive potential of the lake was revealed by mean values for total Kjeldahl nitrogen (0.28 mg/l) and total phosphorus (0.020 mg/l), two nutrients critical for aquatic plant and algal growth.

Algal levels, as measured by chlorophyll a concentrations, were relatively low during the sampling periods. However, the nutrient results showed that troublesome levels of algae could materialize with the onset of suitable environmental conditions.

Balsam Lake was generally well within the OWRC bacteriological criteria for total body contact recreational use. However, on at least one occasion, bacterial concentrations following a heavy rainfall, increased to levels constituting a public health hazard. Consistently high bacterial levels were observed in the Gull River downstream from the Police Village of Coboconk during the 1970 and 1971 surveys.

In view of the existing nutrient concentrations and evidence which indicates that bacterial inputs of artificial origin gained access to the lake, the lake will receive a high priority for a Cottage Pollution Control Survey by staff of the Private Waste and Water Management Branch of the Ministry of the Environment for 1973.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw or inadequately treated wastes must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources

other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a preliminary study on Balsam Lake in 1970 and a detailed study in the summer of 1971. This study included the assessment of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Physical, chemical and biological surveys were conducted four times in 1971. Three bacteriological surveys were also conducted; a spring survey from June 18 to 22, a mid-summer survey from July 23 to August 2 and a fall survey from September 10 to 14 inclusive. Sampling each day for a minimum of five days is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

The "Kawartha Lakes Water Management Study" was also initiated in 1971 to examine the complex problems of eutrophication which exist in the Kawartha Lakes. The broad objective of this study is to develop a water management plan to protect and develop the recreational

potential of the watershed. Included in this study are programs to evaluate the trophic status of the lakes, the sources of nutrients to the lakes, the nutrient cycling systems within the lakes and the specific effects on the water environment of various wastewater inputs. An experiment is also planned to evaluate weed cropping, both as a method of enhancing the recreational use of a lake and of providing a nutrient drain that could significantly reduce the quantity of nutrients available for plant growth in the future. Along with this experiment, effects of weed cropping on the sports fishery of a lake is being evaluated by fisheries biologists of the Department of Lands and Forests (now within the Ministry of Natural Resources). The study is expected to continue for at least three years and some data from the first year is included in this report.

A joint federal-provincial study committee (CORTS) has recently released a report entitled "The Rideau-Trent-Severn - Yesterday Today Tomorrow" which considers optimum recreational development of the Rideau-Trent-Severn waterway corridor which includes part of the Kawartha Lakes. Water and other environmental pollution problems received the highest priority in the list of recommendations in this report which was started in 1967. Other recommendations were made dealing with the use of open space, historical preservation and interpretation, public use areas and other topics designed to develop the corridor as a recreation resource. Many of the recommendations of this report have already been implemented by various federal and provincial agencies such as nutrient budget studies and correction of industrial waste discharges to the water way.

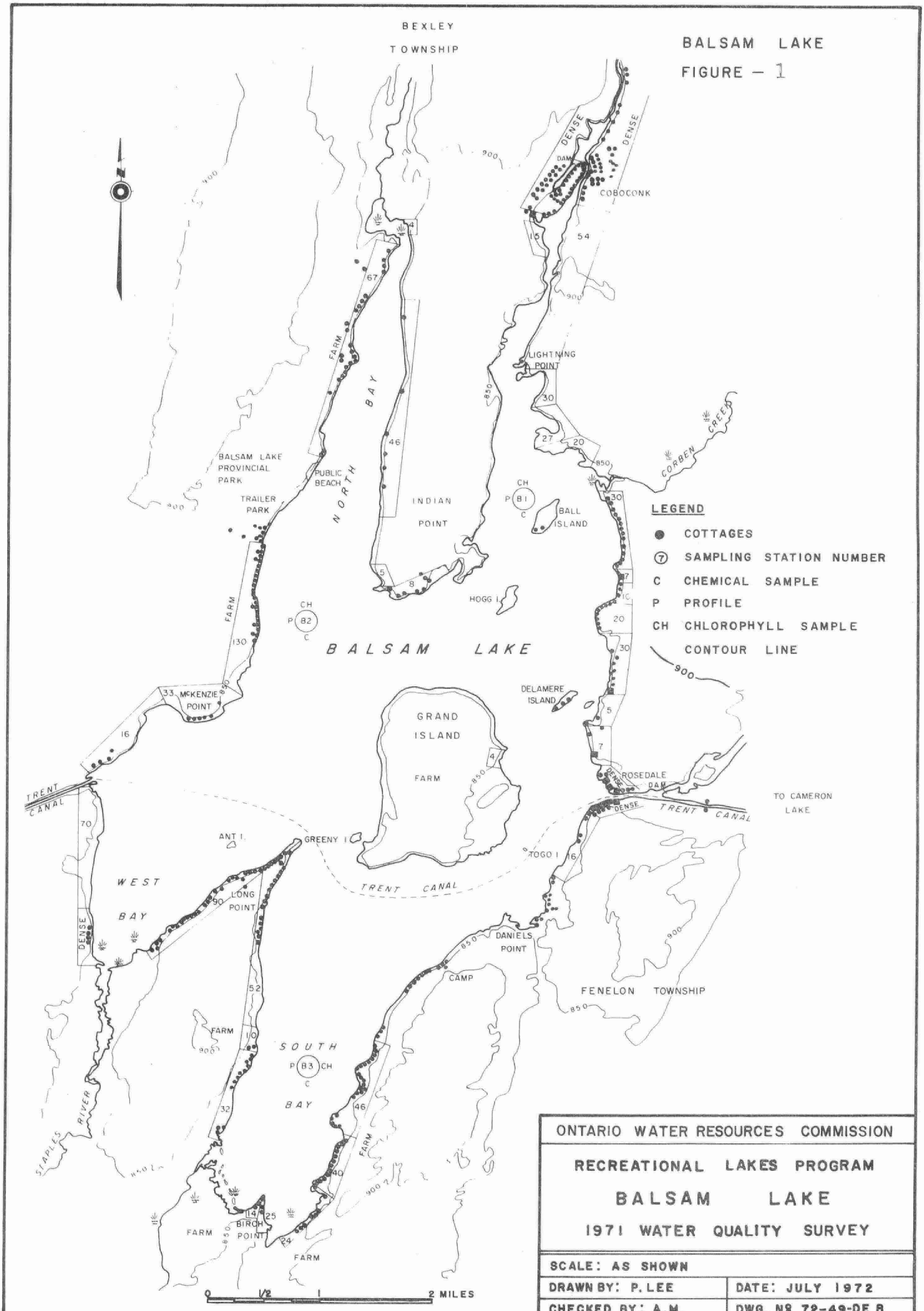
AREA DESCRIPTION

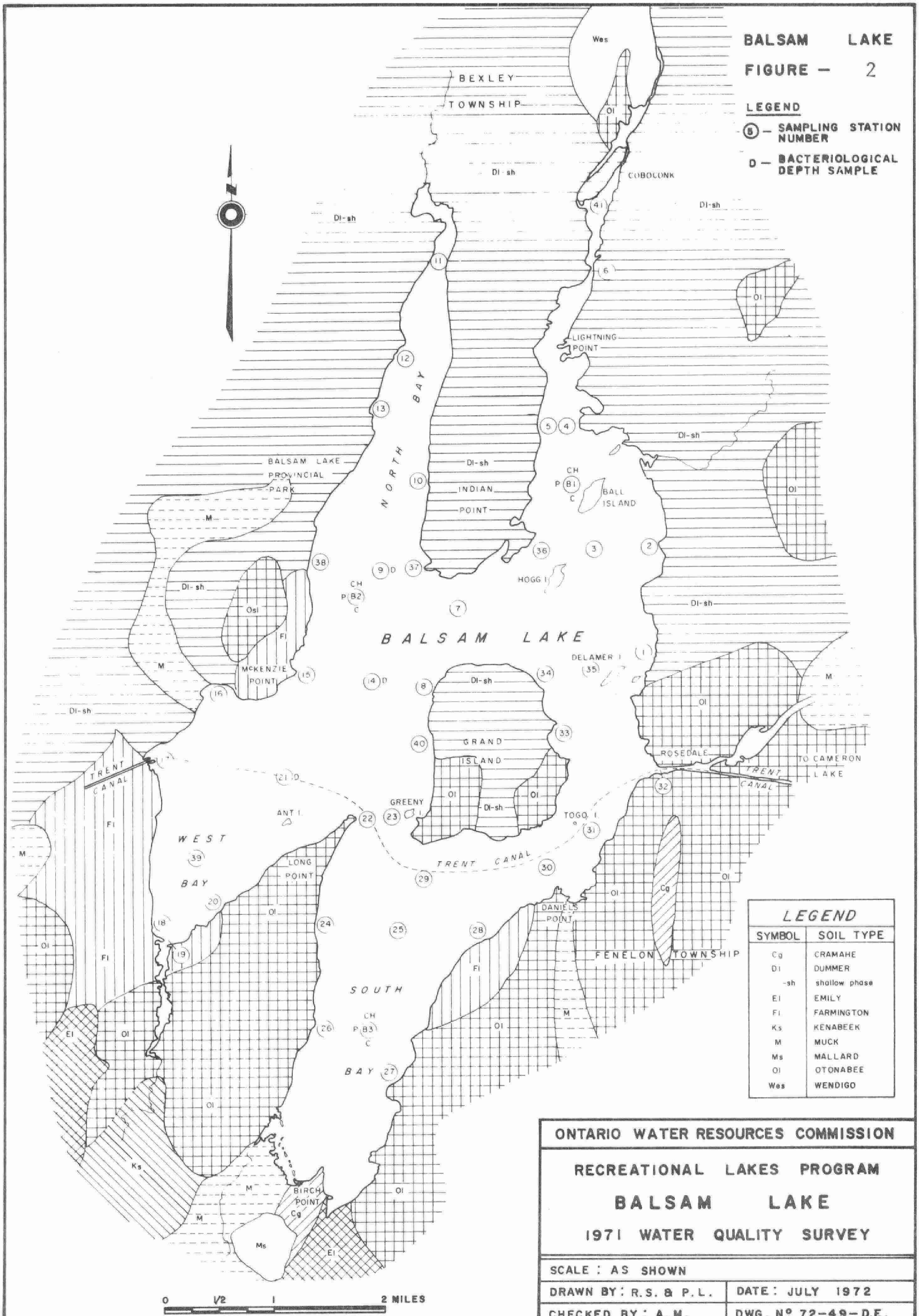
Geography and Topography

Balsam Lake is located in the Townships of Bexley and Fenelon, Victoria County, approximately 29 kilometers (18 miles) north of the Town of Lindsay.

The lake has a maximum depth of 15 meters (49 feet) and a surface area of 47 square kilometers (11,700 acres). It has a shoreline length of 71 kilometers (44 miles) which includes the 9 kilometer (6 miles) shoreline of Grand Island (Figure 1).

The immediate watershed of the lake, excluding the waters flowing into it from the Gull River and Four Mile and Mitchell lakes, consists of 243 square kilometers (59,900 acres) of land. Most of the surrounding area is characterized by a loam type soil belonging to the Dummer-shallow phase and Otonabee and Farmington series. The remainder of the area consists of the Cramahe Gravel and Muck series of soil. The location of these soil types are shown on Figure 2. The predominant soil type is the Dummer-shallow phase series. This series has a relatively thin cover of gravelly, loam till over limestone bedrock although pockets of material over 30 centimeters (12 inches) deep frequently occur. The soil has good drainage and its profile is typical of the Brown Forest soils of Ontario. A striking characteristic is the numerous slabs of bedrock jutting out of the soil. The Otonabee series is a well-drained, calcareous, sandy loam, textured, glacial till, containing a moderate amount of stone. Its profile development shows some of the characteristics of both the Brown Forest Great Soil Group and of the Grey Brown Podzolic soils. The Farmington series is a thin, moderately stony, glacial till over limestone bedrock. Generally the area has little or no overburden. The soil belonging to the Cramahe Gravel series consists of coarse, calcareous sand and gravel, cobbles and large boulders. It is very


BALSAM LAKE
FIGURE — 1
BEXLEY
TOWNSHIP
COBOCONK
DAM
DENSE
LIGHTNING POINT
CORBEN CREEK
BALSAM LAKE PROVINCIAL PARK
TRAILER PARK
PUBLIC BEACH
NORTH BAY
INDIAN POINT
BALL ISLAND
HOGG I.
FARM
McKENZIE POINT
BALSAM LAKE
GRAND ISLAND
DELAMERE ISLAND
ROSEDALE DAM
TO CAMERON LAKE
TRENT CANAL
ANT I.
GREENY I.
TOGO I.
WEST BAY
LONG POINT
DANIELS POINT
CAMP
FENELON TOWNSHIP
SOUTH BAY
STAPLES RIVER
BIRCH POINT
LEGEND
COTTAGES
SAMPLING STATION NUMBER
C CHEMICAL SAMPLE
P PROFILE
CH CHLOROPHYLL SAMPLE
CONTOUR LINE
0 1/2 1 2 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
BALSAM LAKE
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
DRAWN BY: P. LEE
DATE: JULY 1972
CHECKED BY: A.M.
DWG. Nº 72-49-DE 8



BALSAM LAKE
FIGURE — 2
LEGEND
(5) — SAMPLING STATION NUMBER
D — BACTERIOLOGICAL DEPTH SAMPLE
BEXLEY TOWNSHIP
COBOCONK
LIGHTNING POINT
NORTH BAY
BALSAM LAKE PROVINCIAL PARK
INDIAN POINT
BALL ISLAND
HOGG I.
BALSAM LAKE
McKENZIE POINT
DELAMER I.
GRAND ISLAND
ROSEDALE
TO CAMERON LAKE
TRENT CANAL
GREENY I.
ANT I.
TOGO I.
WEST BAY
LONG POINT
DANIELS POINT
FENELON TOWNSHIP
SOUTH BAY
BIRCH POINT
LEGEND
SYMBOL | SOIL TYPE
Cg CRAMAHE
Di DUMMER
-sh shallow phase
El EMILY
Fi FARMINGTON
Ks KENABEEK
M MUCK
Ms MALLARD
Ol OTONABEE
Wes WENDIGO
0 1/2 1 2 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
BALSAM LAKE
1971 WATER QUALITY SURVEY
SCALE : AS SHOWN
DRAWN BY : R.S. & P.L.
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DWG. Nº 72-49-D.E.

stony and has good drainage. The Muck series is made up of organic deposits found in old glacial spillway channels and other depressional areas. This series has 46 centimeters (18 inches) or more of organic material consisting of decomposed remains of sedges and trees overlying a mineral soil. With the exception of the Otonabee series and the Cramahe Gravel series, the soil depth is less than the five feet required by the Ministry of the Environment for the installation of standard subsurface septic tank systems.

Climatic Range

The area has a mean daily temperature of -8°C (17°F) in January and a mean daily temperature of 20°C (68°F) in July. The mean annual precipitation is 80 centimeters (32 inches) including 200 centimeters (80 inches) of snow. According to meteorological reports, the area enjoys about 240 days yearly with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow, provides for participation in most winter sports.

Water Movement

Balsam Lake is part of the Bay of Quinte Terminal Drainage Basin. It is one of the Kawartha Lakes which serve as great reservoirs for the Trent River System. The waters of the system enter the lake from the north-west end of West Bay via the Trent Canal and leave through its only outlet at the mid-point of the lakes's east shore (Rosedale) via the Rosedale River. The lake's other inflows are: the Gull River which enters at the north-east tip of the lake by Coboconk, and Corben Creek which enters the lake just south of the Gull River and flows from Four Mile Lake. Lock 35 is situated on the Rosedale River and is operated by the Federal Ministry of Transport Canals Division, Trent Canal System. It has a drop of 1 meter (3.5 feet).

Shoreline Development

The shoreline of Balsam Lake is well developed with the exception of the west shore of the north-east bay and both sides of Daniels Point (Figure 1). There are approximately 2,000 closely spaced summer cottages, 12 privately owned resorts, a trailer camp, a large public bathing beach and a provincial park on the lake.

Water Usage

The majority of cottage owners and the Hamlet of Rosedale use the lake as their source of domestic water supply. Most residents of Coboconk obtain their water supply from private wells. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. Fishing for bass, pickerel and maskinonge is reasonably good.

Balsam Lake is part of the Trent Canal System and according to the Department of Tourism and Information, 18,516 boats used the system in 1969. Boaters spent an estimated $8.6 million and an additional $3.6 million was spent by the Federal Department of Transport for operation, maintenance and capital expenditure. Thus, $12.2 million was injected into the economy of those areas adjacent to the Trent Canal in 1969.

Presently, there are no direct discharges of wastes into Balsam Lake from municipal or industrial sewage treatment facilities. The area residents are provided with a municipal solid waste disposal site located outside Coboconk on Lot 13, Concession IV, Township of Somerville. This site is scheduled to be abandoned in the spring of 1972 and a new site is being proposed. There is a private site located north of Rosedale on Lot 5, Front Range, Township of Somerville, which may be a potential source of pollution. It is presently under investigation by the Waste Management Branch, Ministry of the Environment.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field and Laboratory Methods

In selecting the physical, chemical and biological sampling sites on Balsam Lake an endeavour was made to choose the deepest locations. As well, a sufficient number of additional stations were sampled to represent adequately the entire lake (Figure 1.).

Temperature profiles were determined at each station using a telethermometer. Dissolved oxygen levels were measured using the alkalide azide modification of the Winkler method (Standard Methods 13th Edition). Additionally, samples for pH, total alkalinity and free carbon dioxide were collected 1m below the surface and 1m above bottom using a Van Dorn water sampler. The total alkalinity and free carbon dioxide concentrations were determined titrimetrically at the mobile laboratory located at Trent University, Peterborough.

At each station, two 32-ounce samples were collected using a composite sampler lowered through the euphotic zone (2x Secchi disc) or lowered to 1m above bottom whichever was less. One sample, for chlorophyll analysis, was immediately preserved with 10 - 15 drops of 2% $MgCO_3$ suspension. The second was divided into two sub-samples; the first sub-sample was frozen for phosphorus and nitrogen analyses, and the second was refrigerated and subsequently analyzed for iron and hardness. In addition when the euphotic zone did not extend to the bottom, samples were collected from 1m above the sediment using a Van Dorn sampler and submitted for phosphorus, nitrogen, iron and hardness.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths from 600 to 750 mμ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five-day intensive bacteriological surveys were completed on Balsam Lake during June and September and an eleven day intensive survey during July - August. In the June and July - August survey, 41 stations were sampled each day at a depth of 1 meter below the surface using sterile, autoclavable, polycarbonate 250 ml bottles. Additional samples were collected at Stations 9D, 14D and 21D (Figure 1). one meter above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes. In the September survey, Stations 5, 9, 9D, 21, 21D and 31 were deleted. All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration (MF) technique (Standard Methods 13th Edition) except that m-Endo Agar Less (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococci (FS) were used as "indicators" of fecal pollution. The "indicators" are normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing microorganisms

may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the *Escherichia coli* group, closely related bacteria of the genera *Citrobacter* and *Enterobacter*. The *Enterobacter* - *Citrobacter* groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the *Escherichia* group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for *Escherichia coli*, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped by this method into areas or groups of stations with the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration can be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm was calculated on each station and for each parameter. The validity of the analyses of variance program (ANOVA-CRE: Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Both these assumptions were checked on Balsam

Lake. The Bartlett's test was found to be non-significant and the data followed a normal distribution, so the analysis of variance (F-test; Sokal, 1969) was calculated in all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S. E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

On Balsam Lake, three stations were established for measuring temperature and dissolved oxygen profiles (B-1, B-2 and B-3; Figure 1).

In June, a zone of rapid temperature decline was apparent immediately above the bottom (Figure 3a). Thermal stratification, or distinct temperature zonation with depth, was not observed during the July, August and September surveys owing to wind-induced mixing (Figure 3b,c and d). Temperature differences between the surface and bottom strata were generally less than 3°C. Surface temperatures averaged 23.4°C, 20.4°C, 23.4°C and 15.5°C for June, July, August and September respectively. Colder water temperatures observed during September (Figure 3d) indicated that autumnal cooling of the lake was occurring.

Relatively homogeneous surface water conditions, with respect to dissolved oxygen, were observed during the Study (Table 1). However, at Stations B-1, and B-2, the two deep-water stations, low oxygen saturations were evident near the bottom during the June survey. These deep-water oxygen deficiencies resulted from bacterial oxidation of organic matter, biological respiration and chemical oxidation. Uniform oxygen saturations in the water column were apparent during July, August, and September (Figure 3B, c and d). The shallow depth of Station B-3 and the heavy aquatic macrophyte growth in the area were responsible for consistently high oxygen concentrations (Table 1).

pH, Free Carbon Dioxide, Total Alkalinity, Hardness and Conductivity

Surface pH values in Balsam Lake were near-neutral (Table 1), and showed only minor fluctuations throughout the season. Higher values were usually found in the surface waters than in the bottom waters. For example,

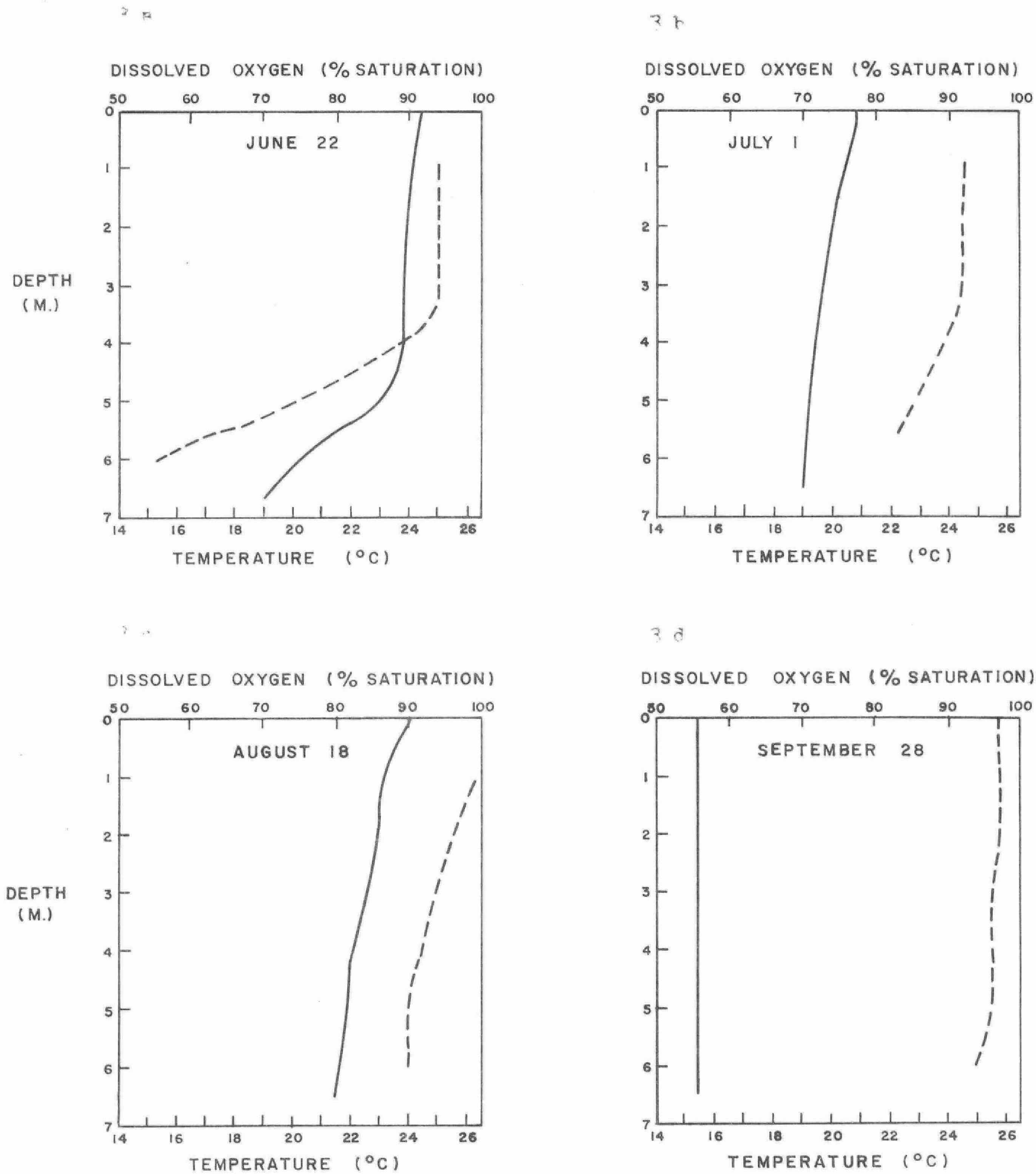


FIGURE 3 : DISSOLVED OXYGEN AND TEMPERATURE PROFILES AT STATION B-1 IN BALSAM LAKE.

- - - - - DISSOLVED OXYGEN

——— TEMPERATURE

at Station B-2 on July 21st, values at 1m and 9.5m were 7.6 and 7.3 respectively.

In the surface waters, carbon dioxide concentrations were low throughout the year (Table 1). Concentrations were higher in the deeper waters than in the surface strata, during June at Station B-1 and during June, July and August at Station B-2. Specifically, on July 21 at Station B-1, values at 1m and 9.5m were 2.1 and 3.5 respectively. The high carbon dioxide levels in the deeper strata, as well as the depressed values mentioned above are related to conditions of organic decomposition.

Alkalinity and hardness values for Balsam Lake were high in June and gradually decreased throughout the sampling season. Mean values for the June, July, August and September sampling surveys were 50 mg/l, 42 mg/l, 39 mg/l and 34 mg/l for alkalinity and 58 mg/l, 55 mg/l, 52 mg/l and 45 mg/l for hardness respectively. The seasonal change to softer water related primarily to dilution from inflowing headwater streams originating in the Haliburton Highlands, a soft-water area in the Precambrian Shield, via the Gull River.

The mean concentration for conductivity was 111 umhos/cm^3 and was consistent with the previously mentioned soft-water nature of the lake.

Iron

Euphotic zone and bottom iron concentrations were low with values ranging from 0.00 mg/l to 0.30 mg/l and from 0.00 to 0.15 mg/l respectively. The low bottom water values were evidence that an iron-phosphorus recycling mechanism, which recycles nutrients from the sediments for algal growth, was not occurring during the survey periods.

Total Kjeldahl Nitrogen and Total Phosphorus

Mean values for total Kjeldahl nitrogen (-.29 mg/l) and for total phosphorus (0.020 mg/l) were indicative of the moderately productive status of Balsam Lake. In general, troublesome levels of algae do not appear when total phosphorus concentrations are less than 0.020 mg/l. A "borderline" mean value for total phosphorus (0.020 mg/l) indicates that troublesome levels of algae could materialize in the lake. Therefore, every effort should be made to prevent any further inputs from municipal drainage, agricultural runoff, inflowing streams and from malfunctioning or improperly installed domestic waste disposal systems, which will serve to accelerate the process of eutrophication.

Chlorophyll a

Algal levels, as reflected by chlorophyll a concentrations, were relatively low during the sampling periods and ranged from 1.6 to 3.6 µg/l. The seasonal mean concentration for all stations was 2.4 µg/l. These low algal levels would not be expected to reduce water quality for recreational activities or diminish the aesthetic quality of the lake. However, the relatively high mean level of total phosphorus was an indication that algal levels could increase to troublesome levels if other environmental conditions were favourable.

As indicated earlier, chlorophyll a measures the amount of photosynethetic green pigment in algae while water clarity which is one of the more important parameters used in defining water quality is determined using a Secchi disc. Recently, Brown (1972) has indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for lakes of Precambrian origin. Figure 4 describes the author's mathematical relationship between chlorophyll a and Secchi disc for 945 sets of data collected from approximately sixty recreational lakes located primarily in Southern Ontario.

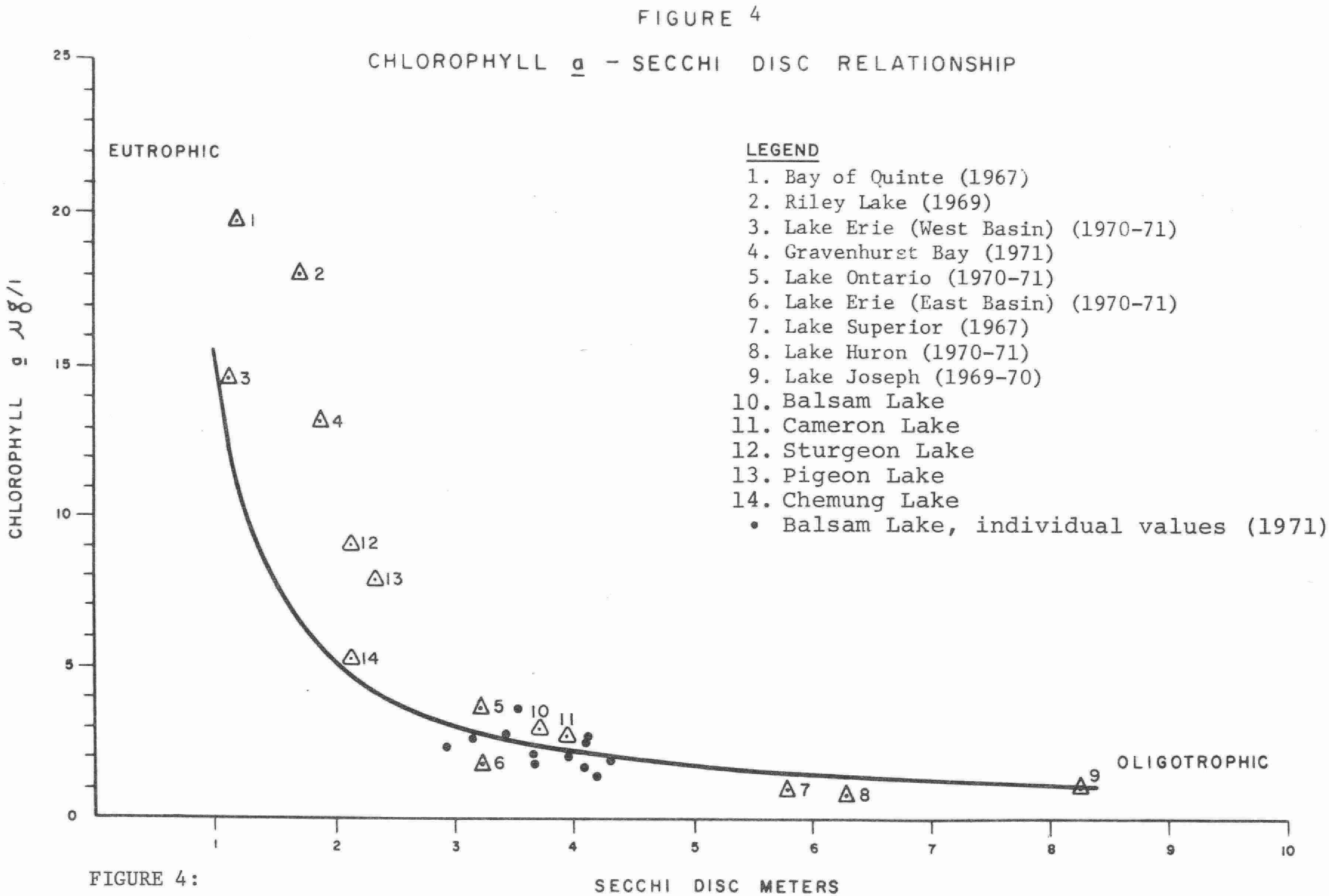


FIGURE 4:

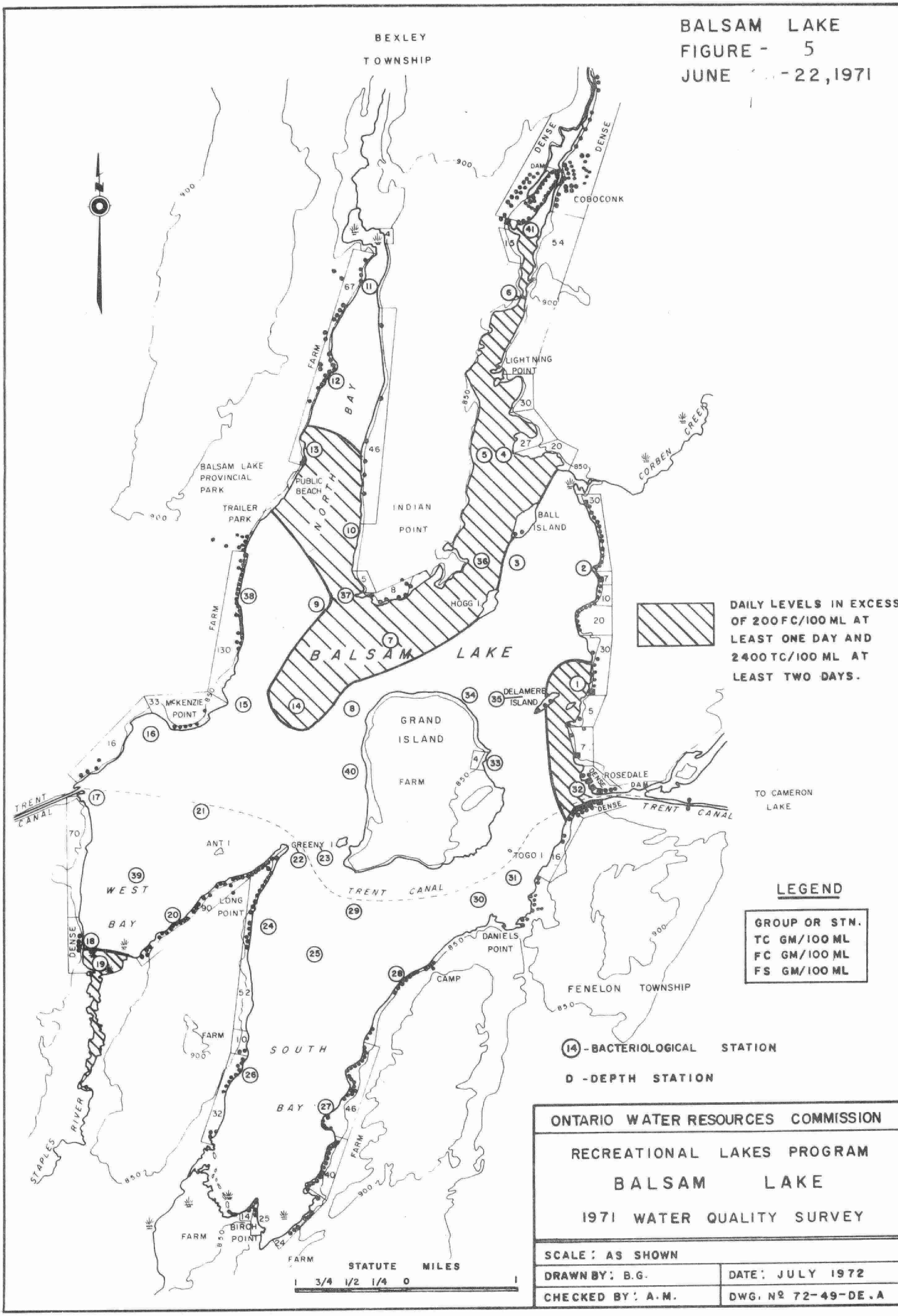
The relationship between chlorophyll a and Secchi disc as determined from the Recreational Lakes surveyed in 1971 as well as the individual and overall mean values of chlorophyll a - Secchi disc for Balsam Lake. The values for the Great Lakes were added for comparative purposes.

Points of eutrophic lakes which are characterized by high chlorophyll a concentrations and poor water clarity are situated along the vertical axis of the hyperbola while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration lie along the horizontal limb. Data for mesotrophic lakes could be dispersed about the middle section of the curve. The oligotrophic to early mesotrophic status of Balsam Lake is indicated (Figure 4) by its proximity to values computed for Lake Ontario and the Eastern Basin of Lake Erie - two oligotrophic to mesotrophic lakes.

Bacteriology

The bacterial levels in Balsam Lake fluctuated widely during the spring five day survey, creating technical difficulties in coutning. On June 18 and 19, the FC and FS levels were low and relatively uniform while the TC levels dropped from an overall mean of 161/100 ml on June 18 to 23/100 ml on June 19. On June 20, the bacterial population increased so drastically that the majority of TC and FC plates were grossly overgrown and uncountable. Even though the bacterial numbers for these stations could not be quantitatively determined, they greatly exceeded the OWRC criteria for total body contact recreational use (OWRC, 1970). The bacterial concentrations remained very high on June 21, and many of the plates, especially TC, were overgrown (Table 9).

By June 22, the last day of the survey, the FC and FS populations had decreased to very low levels for most stations. The TC numbers decreased as well, over most of the lake to levels similar to those of June 18, except for the section of the lake between the Police Village of Coboconk and Grand Island where the recreational use criteria were still exceeded.


BALSAM LAKE
FIGURE - 5
JUNE -22,1971
BEXLEY
TOWNSHIP
COBOCONK
DENSE
DAM
LIGHTNING POINT
CORBEN CREEK
BALSAM LAKE PROVINCIAL PARK
PUBLIC BEACH
TRAILER PARK
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ANT I.
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TOGO I.
WEST BAY
LONG POINT
DANIELS POINT
CAMP
FENELON TOWNSHIP
SOUTH BAY
STAPLES RIVER
BIRCH POINT
DAILY LEVELS IN EXCESS OF 200 FC/100 ML AT LEAST ONE DAY AND 2400 TC/100 ML AT LEAST TWO DAYS.
LEGEND
GROUP OR STN.
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
(14) - BACTERIOLOGICAL STATION
D - DEPTH STATION
STATUTE MILES
1 3/4 1/2 1/4 0 1
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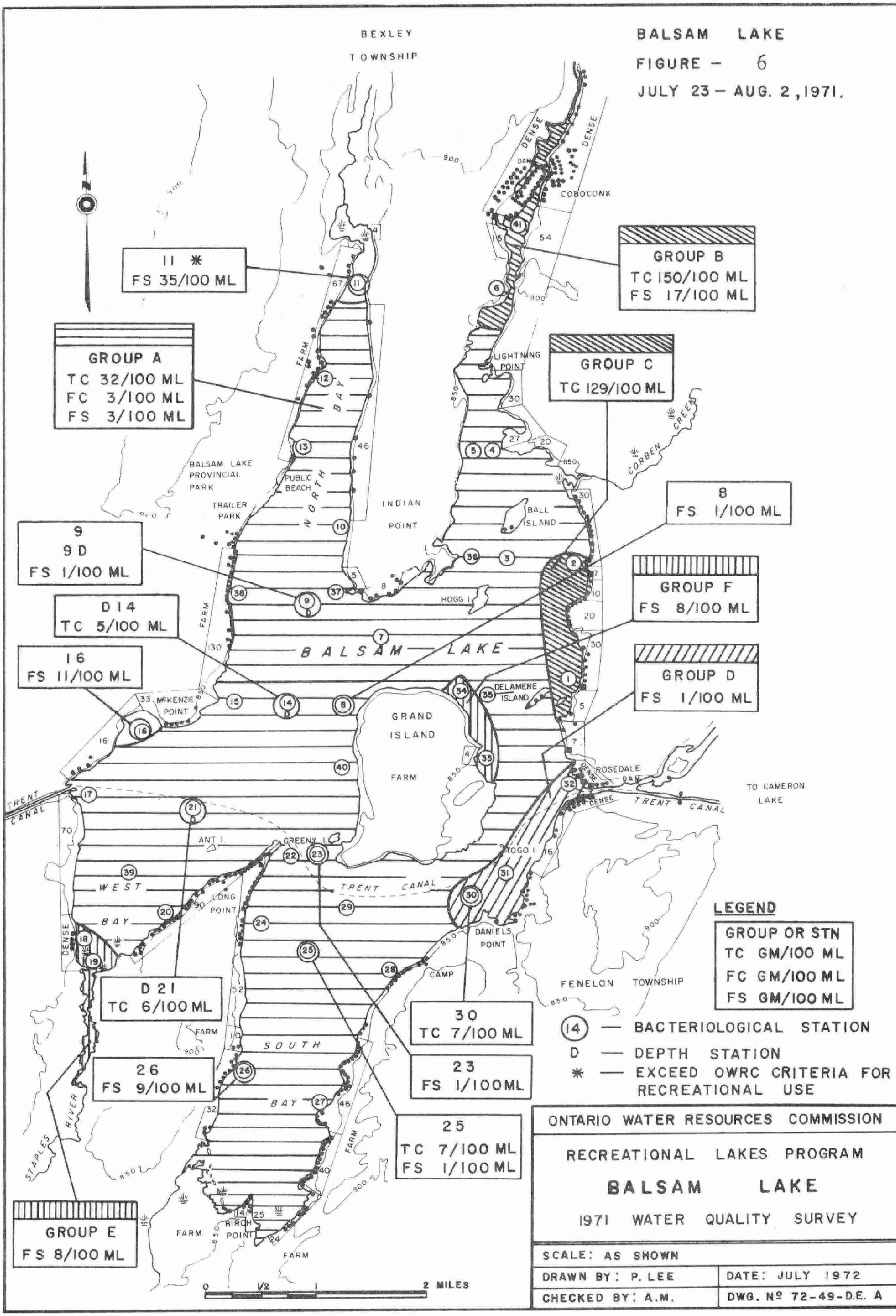
Stations 1, 4, 5, 6, 7, 10, 13, 14, 16, 19, 32 and 36 showed the greatest increase in TC and FC levels on the last three days of the June survey (Table 9, Figure 5). Each of these stations was located at, or downstream from, a heavily developed area. The high levels at these stations on June 21 and 22 were attributable to rainfall induced runoff. The Lindsay Climatological Station recorded 1.48 inches of rainfall for June 20. In contrast to the rest of the lake, the stations in the less heavily developed South Bay and West Bay, except Stations 16 and 19, remained relatively constant for FC, and to a lesser extent, for TC and FS during this survey.

In July, the majority of lake stations ere included in Group A (Figure 6), with overall bacterial means of 32 TC/100 ml, 3 FC/100 ml and 3 FS/100 1 (Tables 3,4,5). The northeast section of the Lake (Group B), immediately downstream from the Police Village of Coboconk on the Gull River, had TC and FS levels significantly higher than Group A (Figure 6, Tables 4, 6). These higher levels were attributed to a bacterial input from the river.

Group C, bordered by a heavily cottaged shoreline, displayed a higher TC level of 129/100 ml, while Stations 14D, 21D, 25 and 30 (geometric mean TC levels of 5/100 ml, 6/100 ml, 7/100 ml and 7/100 ml respectively) were significantly lower than Group A (Figure 6). Each of these isolated stations was located well offshore.

In July, Stations 8, 9 9D and 23 and Group D, all with 1 FS/100 ml, were significantly lower than Group A. In contrast, Group E and Station 11, near swamp-fed inflows, had significantly higher FS levels of 8/100 ml and 35/100 ml respectively. These higher concentrations were attributed to rainfall induced runoff through the inflows (Figure 6). Station 16 with 11 FS/100 ml, Station 26 with 9, FS/100 ml and Group F, adjacent to a large farm, with 8 FS/100 ml were also higher than Group A.



BALSAM LAKE
FIGURE – 6
JULY 23 – AUG. 2, 1971.
BEXLEY TOWNSHIP
COBOCONK
DENSE
DAM
11 ✳
FS 35/100 ML
GROUP B
TC 150/100 ML
FS 17/100 ML
GROUP A
TC 32/100 ML
FC 3/100 ML
FS 3/100 ML
GROUP C
TC 129/100 ML
LIGHTNING POINT
NORTH BAY
BALSAM LAKE PROVINCIAL PARK
PUBLIC BEACH
TRAILER PARK
INDIAN POINT
BALL ISLAND
CORBEN CREEK
8
FS 1/100 ML
9
9 D
FS 1/100 ML
HOGG I.
GROUP F
FS 8/100 ML
D 14
TC 5/100 ML
BALSAM LAKE
16
FS 11/100 ML
GROUP D
FS 1/100 ML
McKENZIE POINT
DELAMERE ISLAND
GRAND ISLAND
FARM
ROSEDALE DAM
TO CAMERON LAKE
TRENT CANAL
ANT I.
GREENY I.
TOGO I.
WEST BAY
LONG POINT
DANIELS POINT
CAMP
FENELON TOWNSHIP
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
D 21
TC 6/100 ML
30
TC 7/100 ML
(14) — BACTERIOLOGICAL STATION
D — DEPTH STATION
✳ — EXCEED OWRC CRITERIA FOR RECREATIONAL USE
26
FS 9/100 ML
23
FS 1/100ML
SOUTH BAY
25
TC 7/100 ML
FS 1/100 ML
STAPLES RIVER
GROUP E
FS 8/100 ML
BIRCH POINT
0 1/2 1 2 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
BALSAM LAKE
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
DRAWN BY: P. LEE
DATE: JULY 1972
CHECKED BY: A.M.
DWG. Nº 72-49-D.E. A

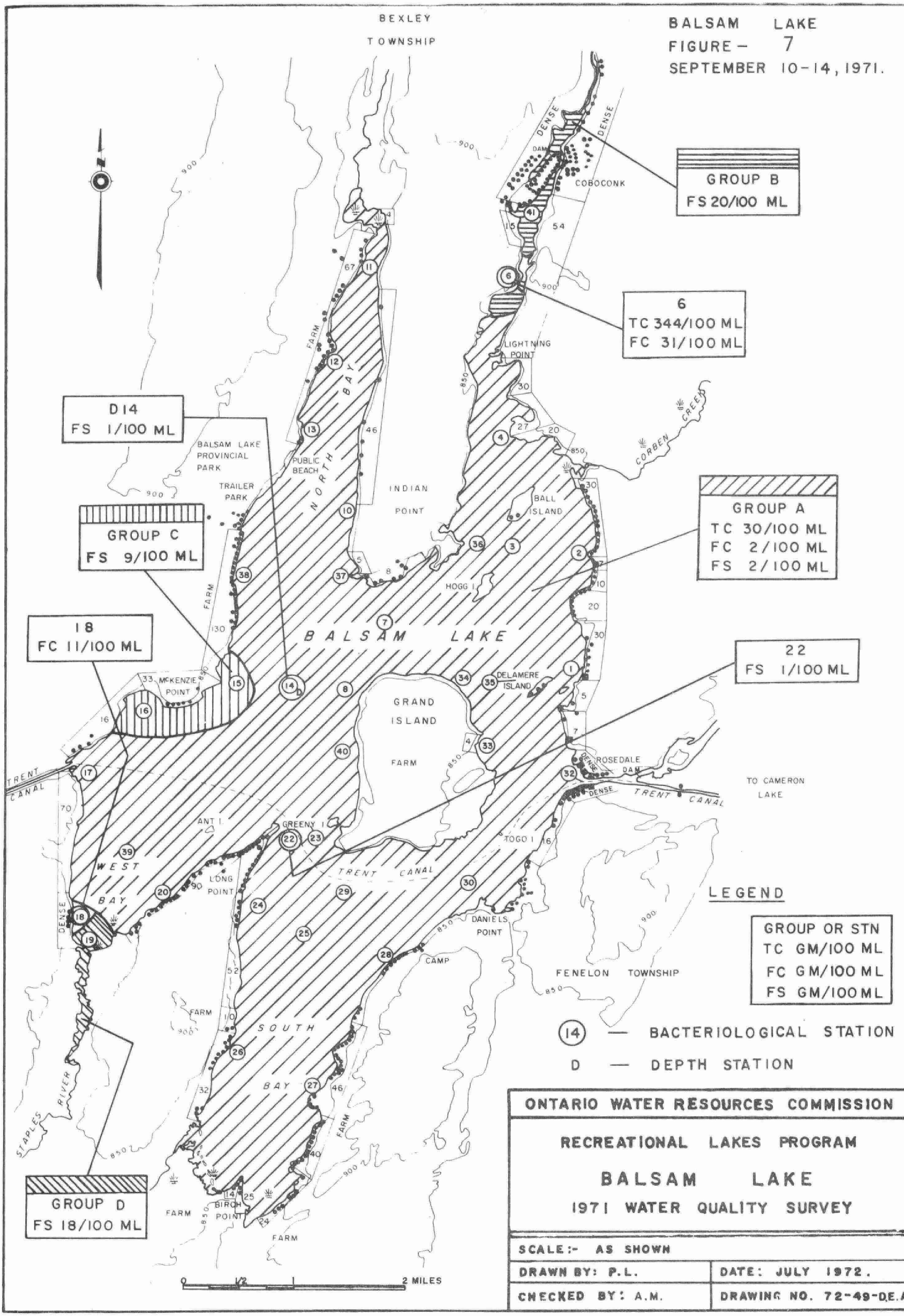
BALSAM LAKE

The Lindsay Climatological Station recorded a total of 1.48 inches of rain during the June survey period and 1.55 inches during the July survey. In contrast to the June survey, in which the bacterial population fluctuated widely following the rainfall, no noticeable fluctuations were observed in July. It follows that rainfall alone is not the sole cause of increased bacterial levels. Given saturated soil conditions as was probable in June, rain would cause more runoff than if the soil was drier as it normally is in mid-summer.

In the September survey, the majority of lake stations were included in Group A (Figure 7, Tables 3, 4, 5) with overall bacterial geometric means of 30 TC/100 ml, 2 FC/100 ml and 2 FS/100 ml. Group B (Stations 6 and 41) was significantly higher than Group A with 20 FS/100 ml. Station 41 with 154 TC/100 ml and Station 6 with significantly higher bacterial concentrations of 344 TC/100 ml and 31 FC/100 ml, were indicating a bacterial input from the Village of Coboconk (Figure 7).

Group D with 18 FS/100 ml was influenced from the swamp-fed inflow of the Staples River. Station 18, within Group D, adjacent to a heavily cottaged area, also had a higher FC level of 11/100 ml.

The TC, FC, and FS levels remained uniformly low during the July and September Balsam Lake surveys. Both surveys demonstrated bacterial inputs from the Gull and Staples rivers. The July and September surveys were not compared statistically to the June survey, since the June survey data was not analyzed by the analysis of variance program. Balsam Lake in June appeared to be very susceptible to bacterial contaminated runoff with fluctuating bacterial populations resulting in a short-term public health hazard.


BALSAM LAKE
FIGURE - 7
SEPTEMBER 10-14, 1971.
BEXLEY
TOWNSHIP
GROUP B
FS 20/100 ML
6
TC 344/100 ML
FC 31/100 ML
D14
FS 1/100 ML
GROUP A
TC 30/100 ML
FC 2/100 ML
FS 2/100 ML
GROUP C
FS 9/100 ML
18
FC 11/100 ML
22
FS 1/100 ML
GROUP D
FS 18/100 ML
COBOCONK
LIGHTNING POINT
CORBEN CREEK
BALSAM LAKE PROVINCIAL PARK
PUBLIC BEACH
TRAILER PARK
NORTH BAY
INDIAN POINT
BALL ISLAND
HOGG I.
BALSAM LAKE
McKENZIE POINT
DELAMERE ISLAND
GRAND ISLAND
FARM
ROSEDALE DAM
TRENT CANAL
TO CAMERON LAKE
ANT I.
GREENY I.
TOGO I.
WEST BAY
LONG POINT
DANIELS POINT
CAMP
FENELON TOWNSHIP
SOUTH BAY
STAPLES RIVER
BIRCH POINT
DENSE
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
(14) — BACTERIOLOGICAL STATION
D — DEPTH STATION
0 1/2 1 2 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
BALSAM LAKE
1971 WATER QUALITY SURVEY
SCALE:- AS SHOWN
DRAWN BY: P.L.
DATE: JULY 1972.
CHECKED BY: A.M.
DRAWING NO. 72-49-D.E.A

Balsam Lake was surveyed twice in 1970 and the data was compared to the 1971 data. The station locations in the 1970 surveys were identical to those of 1971 except for the addition of Stations 36 to 41, in 1971.

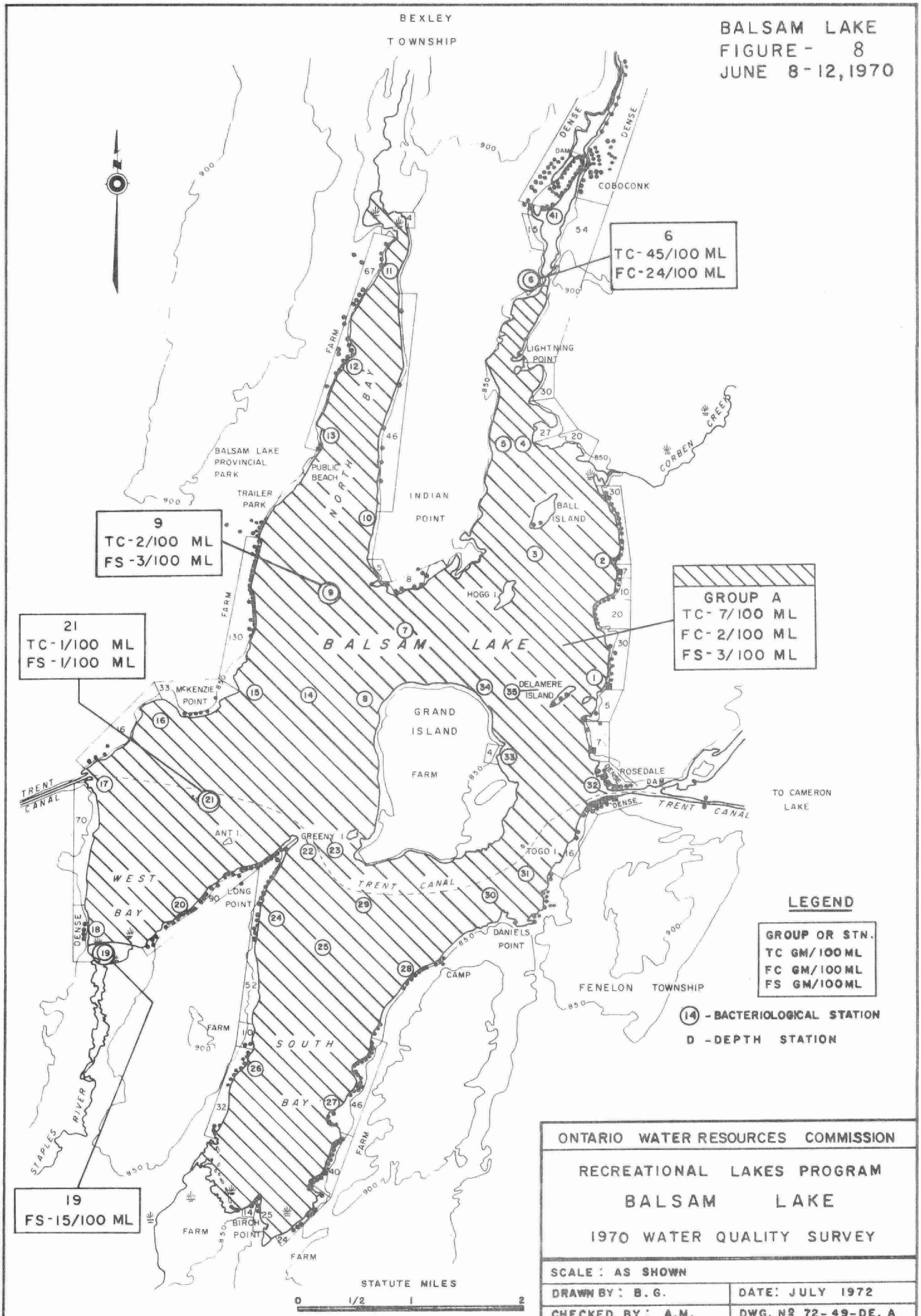
Briefly, in the 1970 June survey, all stations were included in Group A with 7 TC/100 ml, 2 FC/100 ml and 3 FS/100 ml (Figure 8) except Station 6, downstream from Coboconk, had higher TC and FC levels and the mid-lake Stations 9 and 21 which had lower TC and FC levels than Group A (Tables 6, 7, 8).

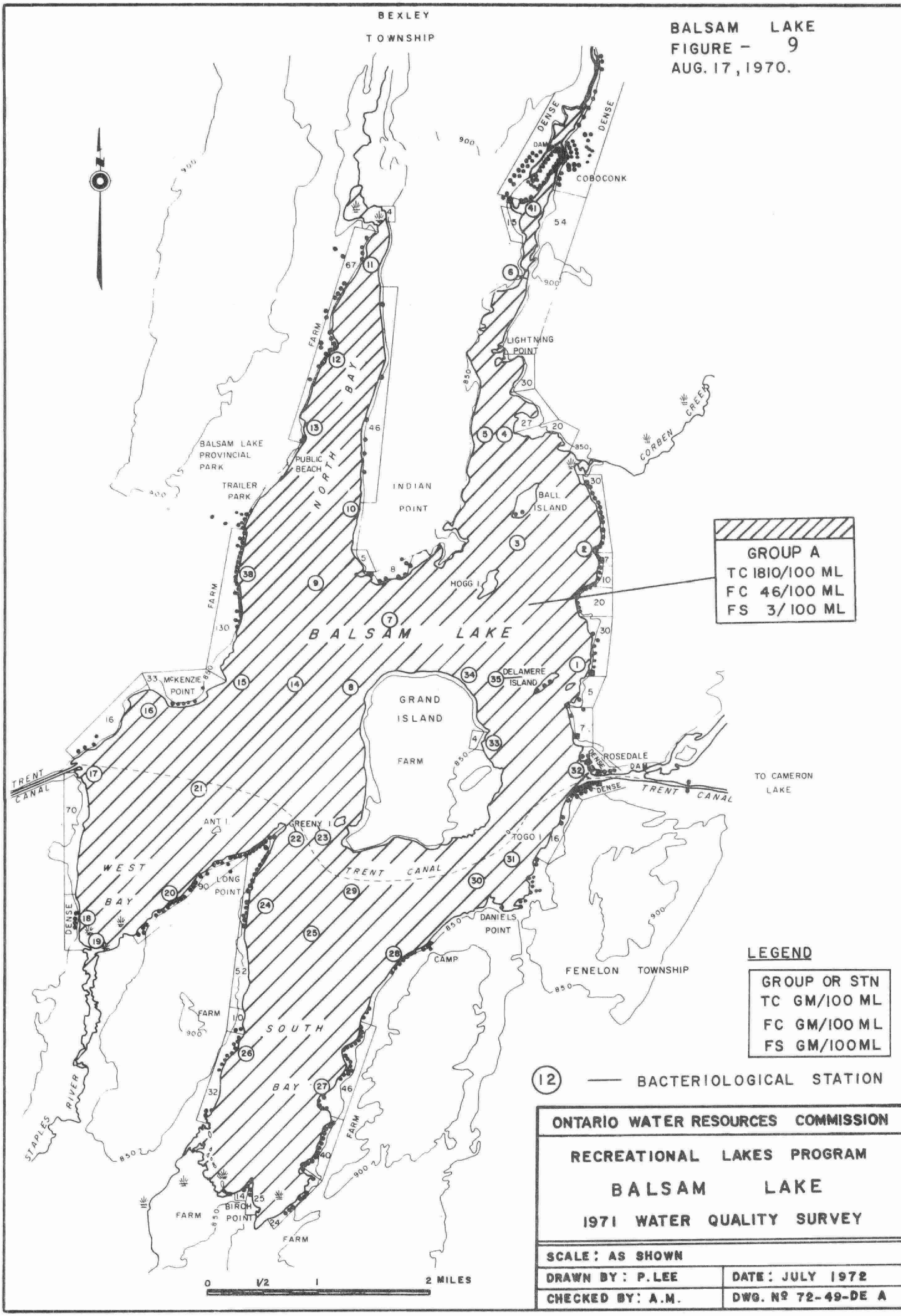
During the August 1970 survey, the entire lake was homogeneous (Group A) with bacterial levels of 1,810 TC/100 ml, 46 FC/100 ml and 3 FS/100 ml (Figure 9, Tables 6, 7, 8).

The TC and FC densities in August (1970) were significantly higher than in June while the FS levels were uniformly low in both surveys. Thus, the increased levels were attributed to domestic rather than natural pollution (Geldreich, 1968).

The five surveys completed on Balsam Lake in 1970 and 1971 demonstrated wide fluctuations in TC and FC concentrations. In contrast, the FS levels in all surveys remained very low.

The two June surveys presented very different pictures of the lake. The 1970 June survey showed Balsam Lake to be bacteriologically acceptable, while the 1971 survey following heavy rainfall showed a lake which exceeded the OWRC criteria for recreational use.


BALSAM LAKE
FIGURE - 8
JUNE 8-12, 1970
BEXLEY
TOWNSHIP
COBOCONK
DAM
DENSE
6
TC-45/100 ML
FC-24/100 ML
LIGHTNING POINT
CORBEN CREEK
BALSAM LAKE PROVINCIAL PARK
PUBLIC BEACH
TRAILER PARK
NORTH BAY
INDIAN POINT
BALL ISLAND
HOGG I.
9
TC-2/100 ML
FS-3/100 ML
GROUP A
TC- 7/100 ML
FC- 2/100 ML
FS- 3/100 ML
21
TC-1/100 ML
FS-1/100 ML
BALSAM LAKE
McKENZIE POINT
GRAND ISLAND
FARM
DELAMERE ISLAND
ROSEDALE DAM
TRENT CANAL
TO CAMERON LAKE
ANT I.
GREENY I.
TOGO I.
WEST BAY
LONG POINT
DANIELS POINT
CAMP
FENELON TOWNSHIP
LEGEND
GROUP OR STN.
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
14 - BACTERIOLOGICAL STATION
D - DEPTH STATION
SOUTH BAY
STAPLES RIVER
19
FS-15/100 ML
BIRCH POINT
STATUTE MILES
0 1/2 1 2
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
BALSAM LAKE
1970 WATER QUALITY SURVEY
SCALE : AS SHOWN
DRAWN BY : B. G.
DATE: JULY 1972
CHECKED BY : A.M.
DWG. Nº 72-49-DE. A



ONTARIO WATER RESOURCES COMMISSION	
RECREATIONAL LAKES PROGRAM	
BALSAM LAKE	
1971 WATER QUALITY SURVEY	
SCALE: AS SHOWN	
DRAWN BY: P. LEE	DATE: JULY 1972
CHECKED BY: A.M.	DWG. Nº 72-49-DE A

The 1970August survey had much higher TC and FC levels than the 1971 July survey. The high levels in the August, 1970 survey were attributed to domestic pollution input during peak recreational use of the lake.

All surface water, especially that drawn from the region downstream from the Police Village of Coboconk must receive prior treatment, including disinfection, before being considered potable.

Consistently high bacterial levels were observed in the Gull River downstream from the Plice Village of Coboconk during the 1970 and 1971 surveys.

As a result of the findings, the Private Waste and Water Management Branch will be giving high priority to a Cottage Pollution Control Survey in this area in 1973.

Although Balsam Lake was generally within the OWRC recreational use criteria, all surface water must receive prior treatment including disinfection before being considered potable.

Table 1: Dissolved oxygen (percent saturation) pH, free CO_2 (mg/l), alkalinity (mg/l) and conductivity (µmhos/cm^3) ranges at three sampling stations in Balsam Lake during the summer of 1971. Samples were secured from one meter of depth and one meter off the bottom.

STATION	SAMPLE DEPTH	TEMP. ($^{\circ}$C.)	D.O. (% Sat.)	pH	CO_2 (mg/l)	ALKALINITY (mg/l)	CONDUCTIVITY (µmhos/cm^3)
B - 1	1m	15.4 - 24.1	93 - 98	7.0 - 7.4	1.9 - 3.0	22.5 - 40.3	65 - 115
	bottom	15.3 - 21.8	57 - 97	6.9 - 7.2	2.6 - 6.3	12.2 - 45.5	86 - 215
B - 2	1m	15.9 - 23.0	93 - 98	7.4 - 7.6	2.1 - 3.5	29.5 - 52.0	110 - 180
	bottom	15.7 - 21.1	50 - 92	7.1 - 7.4	3.3 - 7.9	39.5 - 55.0	124 - 170
B - 3	1m	15.1 - 24.0	91 - 97	7.4 - 7.5	2.3 - 4.1	39.5 - 54.5	100 - 155
	bottom	15.1 - 22.0	80 - 100	7.3 - 7.7	2.5 - 3.6	39.5 - 53.5	104 - 160

Table 2: Hardness (mg/l), iron (mg/l), total Kjeldahl nitrogen (mg/l), total phosphorus (mg/l P), chlorophyll a (µg/l) and Secchi disc (m) ranges at three locations in Balsam Lake during the summer of 1971. Samples were secured from one (1) meter of depth and one (1) meter off the bottom.

STATION	SAMPLE DEPTH	HARDNESS (mg/l)	Fe (mg/l)	TKN mg N/l	TOTAL P. (mg P/l)	CHLORO A (µg/l)	SECCHI DISC m
B - 1	composite	34 - 48	0.00-0.05	0.14-0.35	.013-.017	1.6 - 2.9	3.3 - 4.2
	bottom	36*	0.05	0.25	.002		
B - 2	composite	52 - 60	0.00-0.30	0.11-0.32	.014-.018	1.8 - 3.6	3.6 - 4.1
	bottom	52 - 62	0.00-0.15	0.21-0.70	.024-.036		
B - 3	composite	52 - 62	0.00-0.05	0.13-0.41	.014-.032	2.0 - 2.9	3.0 - 4.4
	bottom						

* Note: Only one (1) sample was taken at one (1) meter off bottom at Station B-1.

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F - the calculated analysis of variance statistic on F ratio.

df - degrees of freedom of the F ratio for "between group" and "within group" variation.

F(5%) - the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.

log GM - the logarithm (base 10) of the geometric mean.

S.E. - the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N - the number of values in the mean.

GM - the geometric mean of the bacterial level.

t - the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

Table 3

Summary of Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

SURVEY	July 23 - Aug. 2	Sept. 10 - 14
GROUP	All Stations	All Stations
F	2.458	1.511
df	43, 336	37, 132
F(.05)	1.439	1.512
	SD	NSD
GROUP	A	A
	All Stations except 1, 2, 6, 25, 30, 41, 14D, 21D	All stations except 6
F	1.396	1.267
df	35, 276	36, 129
F(.05)	1.46	1.37
	NSD	NSD
log GM	1.5109	1.474
SE	.0445	.0518
N	312	166
GM	32	30
GROUP	B	-
	(Stations 6, 41)	
F	t = .662	
df	16	
F(.05)	t(.05) = 2.12	
	NSD	
log GM	2.175	
SE	.1585	
N	18	
GM	150	

Table 3 (Contd)

SURVEY	July 23 - Aug. 2	Sept. 10 - 14
GROUP	C (stations 1, 2)	
F	t = .1727	
df	17	
F(.05)	t(.05) = 2.11	
	NSD	
log GM	2.1089	
SE	.1552	
N	19	
GM	129	

Table 4

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	July 23 - Aug. 2	Sept. 10 - 14
GROUP	All Stations	All Stations
F	1.290	1.727
df	43, 385	37, 137
F(.05)	1.436	1.510
	NSD	SD
GROUP	A (All stations)	A (All stations except 6, 18)
F	-	.8769
df	-	35, 130
F(.05)	-	1.50
	-	NSD
log GM	.5176	.2813
SE	.0315	.0398
N	429	166
GM	3	2

Table 5

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	July 23 - Aug. 2	Sept. 10 - 14
GROUP	All Stations	All Stations
F	4.563	3.998
df	43, 386	37, 136
F(.05)	1.436	1.510
	SD	SD
GROUP	A All Stations except 6, 8, 9, 11, 16, 18, 19, 23, 25, 26, 30 - 34, 41, 9D	A All Stations except 6, 14, 15, 16, 18, 19, 22, 41
F	1.5954	1.5434
df	26, 233	29, 106
F(.05)	1.61	1.55
	NSD	NSD
log GM	.469	.3181
SE	.0343	.0377
N	260	136
GM	3	2
GROUP	B (stations 6, 41)	B (stations 6, 41)
F	t = .8600	t =.6957
df	18	6
F(.05)	t(.05) = 2.101	t(.05) = 2.447
	NSD	NSD
log GM	1.229	1.2967
SE	.164	.1080
N	20	8
GM	17	20

Table 5 (Cont'd)

SURVEY	July 23 - Aug. 2	Sept. 10 - 14
GROUP	D	C
	(stations 30 - 32)	(stations 15, 16)
F	.136	t = .0679
df	2, 23	8
F(.05)	4.28	t(.05) = 2.306
	NSD	NSD
log GM	.058	.9640
SE	.033	.2058
N	26	10
GM	1	9
GROUP	E	D
	(stations 18, 19)	(stations 18, 19)
F	t = .2968	t = .9434
df	18	8
F(.05)	t(.05) = 2.101	t(.05) = 2.306
	NSD	NSD
log GM	.8804	1.2592
SE	.206	.1727
N	20	10
GM	8	18
GROUP	F	
	(stations 33, 34)	
F	t = .1767	
df	19	
F(.05)	t(.05) = 2.09	
	NSD	
log GM	.901	
SE	.1367	
N	21	
GM	8	

Table 6

Summary of Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

SURVEY	June 8 - 12	Aug. 17 - 21
GROUP	All Stations	All Stations
F	2.670	.773
df	32, 132	34, 109
F(.05)	1.541	1.545
	SD	NSD
GROUP	A	A
	All stations except 6, 9, 21	All stations
F	1.562	-
df	29, 120	-
F(.05)	1.570	-
	NSD	-
log GM	.8592	3.2578
SE	.0409	.0520
N	150	144
GM	7	1810

Table 7

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	June 8 - 12	August 17 - 21
GROUP	All Stations	All Stations
F	2.043	.823
df	32, 132	34, 113
F(.05)	1.541	1.542
	SD	NSD
GROUP	A	A
	All stations except 6	All stations
F	1.247	-
df	31, 128	-
F(.05)	1.550	-
	NSD	-
log GM	.3404	1.6609
SE	.0353	.0597
N	160	148
GM	2	46

Table 8

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	June 8 - 12	August 17 - 21
GROUP	All Stations	All Stations
F	2.175	.777
df	19, 80	34, 125
F(.05)	1.723	1.533
	SD	NSD
GROUP	A	A
	All stations except 9, 19, 21	All Stations
F	1.453	-
df	16, 68	-
F(.05)	1.800	-
	NSD	-
log GM	.4518	.4529
SE	.0582	.0412
N	85	160
GM	3	3

Table 9

Summary of TC and FC Bacterial Levels in Excess of Criteria for Individual Determination, June 20 - 22, 1971

Parameter	Station	June 20	June 21	June 22	Station	June 20	June 21	June 22	Station	June 20	June 21	June 22
TC	1	x	x	x	15	x	x		30	x		
FC		x								x		
TC	2	x	x		16	x	x		31	x		
FC						x						
TC	3	x		x	17		x		32	x	x	
FC										x		
TC	4	x	x		18	x	x		33	x	x	
FC		x										
TC	5	x	x		19	x	x	o	34	x	x	x
FC				o		x	o					
TC	6	x	x	o	20	x	x		35	x	x	x
FC		x										
TC	7	x		x	21	x	x		36	x	x	x
FC		x										x
TC	8				21D				37	x	x	
FC										x		
TC	9	x	x	o	22	x			38	x	x	
FC												
TC	9D				23	x	x		39	x	x	
FC												
TC	10	x	x	o	24		x		40	x	x	
FC		o										
TC	11	x	x		25	x	o		41	x	x	x
FC												
TC	12	x	x		26		o					
FC												
TC	13	x	x		27		x					
FC		x										
TC	14	x	x		28							
FC		x										
TC	14D				29	x	o					
FC												

LEGEND

TC - x - 2400/100 ml
o - 1000 & 2400

FC - x - 200/100 ml
o - 100/100 ml and 200/100 ml

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL a	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

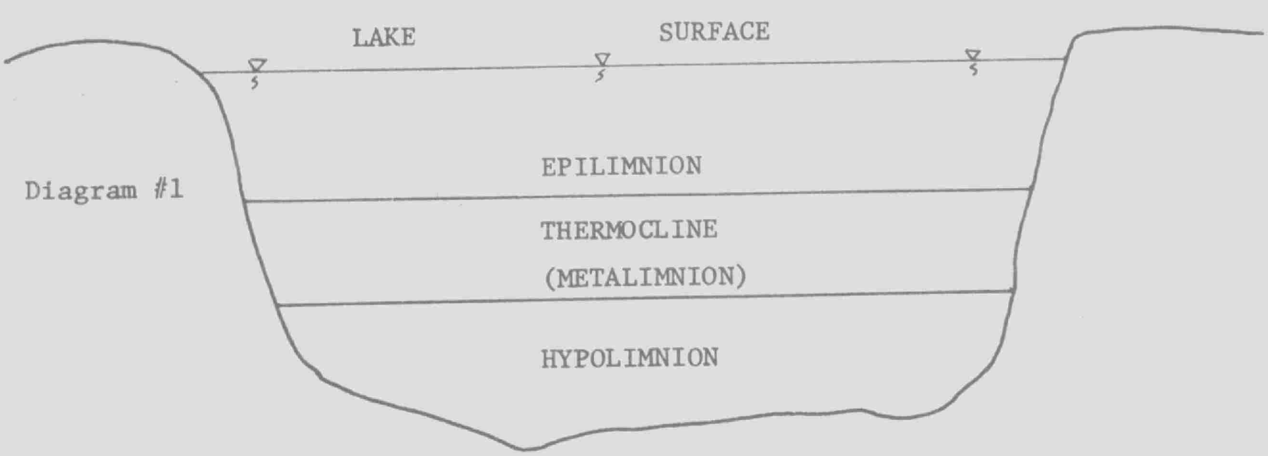
EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC : A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION : During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion) : The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding $1^{o}C$ increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) : Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS : Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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Microbiological Criteria
Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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